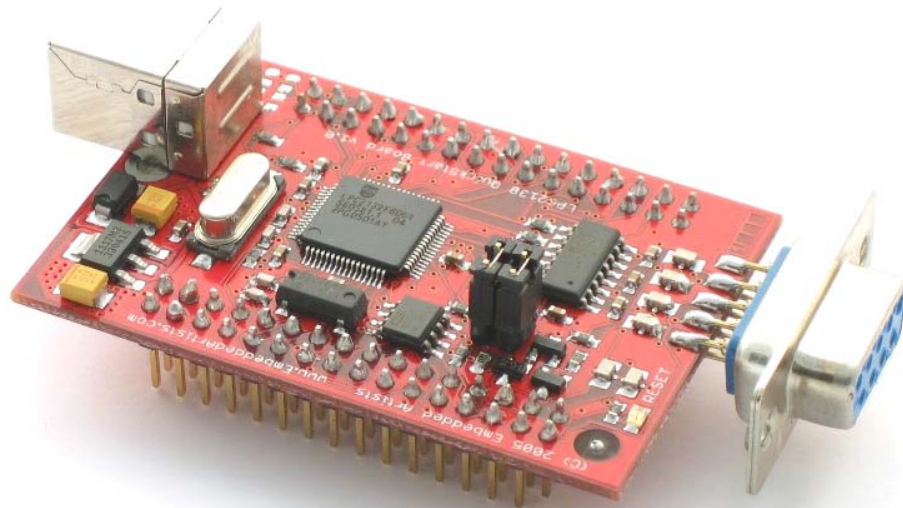


LPC2148 USB QuickStart Board User's Guide



*Get Up-and-Running Quickly and
Start Developing on Day 1...*

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Table of Contents

1	Introduction	4
1.1	Contents	4
1.2	Features	4
1.3	Low Cost	5
1.3.1	Design and Production Services	5
1.4	Other QuickStart Boards and Kits	5
2	Board Design	6
2.1	Board Schematics	6
2.2	Mechanical Dimensions	9
2.3	Examples	10
2.3.1	JTAG	10
2.3.2	Reset	11
2.3.3	I ² C	12
2.3.4	SPI	13
2.3.5	LEDs	14
3	Getting Started	15
3.1	Test program	15
3.2	Program Development	15
4	CD-ROM and Product Registration	16
4.1	CD-ROM	16
4.2	Product Registration	16
5	Further Information	17

1 Introduction

Thank you for buying Embedded Artists' *LPC2148 USB QuickStart Board* based on Philips ARM7TDMI LPC2148 microcontroller.

This document is a User's Guide that describes the *LPC2148 USB QuickStart Board* design along with the accompanying software and program development tools. The document contains information on how to use and integrate the board in your own designs, including electrical and mechanical information.

1.1 Contents

The box received when ordering the *LPC2148 USB QuickStart Board* contains the following:

- The *LPC2148 USB QuickStart Board*.
- CD-ROM which includes additional material and programs, including complete and evaluation versions of different development environments. Observe that bulk orders (10 or 100 boards) only include one CD-ROM.

In addition, the following is needed in order to start developing applications with the *LPC2148 USB QuickStart Board*:

- A DC power supply, 5-10 volt, capable of providing at least 150 mA (more if external circuits need power from the 3.3 volt supply). The *LPC2148 USB QuickStart Board* does not contain reverse polarity protection. Consult the schematic and the LD1117 datasheet for details about the voltage regulator.
- A serial extension cable, DB9-male to DB9-female (DB9M-DM9F), for connecting the *LPC2148 USB QuickStart Board* to a PC.
- A USB cable of type: B-to-A, both male connectors.
- An optional *Prototype QuickStart Board* to quickly get up-and-running with the hardware. See Embedded Artists' homepage for more information about the *Prototype QuickStart Board*.
- An optional JTAG interface, for program development debugging.

1.2 Features

Embedded Artists' *LPC2148 USB QuickStart Board* lets you get up-and-running quickly with Philips ARM7TDMI LPC2148 microcontroller. The small form factor board offers many unique features that ease your development.

- Philips ARM7TDMI LPC2148 microcontroller with 512 KByte program Flash and 32+8 KByte SRAM
- All LPC2148 I/O pins are available on connectors
- 12.0000 MHz crystal for maximum execution speed and standard serial bit rates
 - Phase-locked loop (PLL) multiplies frequency with five; 5 x 12 MHz = 60 MHz
- 32.768kHz RTC crystal
- ESD/EMI protected RS232 channel with DSUB-9 connector
 - Both UART #0 and #1 connected
 - Signals available on expansion connector

- 2 Kbit I²C E²PROM for storing non-volatile parameters
- Onboard low-dropout voltage and reset generation.
 - Generates +3.3V from a single +5V supply
 - +3.3V available for external circuits, up to 300 mA
 - Power supply: 5-10 VDC, at least 150 mA, or via USB connector
- Simple and automatic program download (ISP) via RS232 channel
 - Circuit that automatically controls the bootloader from RS232 channel
- Dimensions: 59 x 39.5 mm
 - Small form factor for easy integration
 - Dual 2x16 pins I/O connectors
 - Four layer PCB (FR-4 material) for best noise immunity

1.3 Low Cost

The *LPC2148 USB QuickStart Board* is very low cost and can be used for prototyping / development as well as for OEM production. Modifications for OEM production can easily be done for volumes > 1k. Contact Embedded Artists for further information about design and production services.

Bulk orders (> 10 boards) can be delivered without pin rows and/or DSUB-9 connector soldered for easy integration with original equipment.

1.3.1 Design and Production Services

Embedded Artists provide design services for custom designs, either completely new or modification to existing boards. Specific peripherals and/or I/O can easily be added to the different designs, for example communication interfaces, specific analogue or digital I/O, and power supplies. Embedded Artists has a broad, and long, experience in designing industrial electronics in general, and specifically with Philips LPC2xxx microcontroller family.

- Prototype and low-volume production takes place in Sweden for best flexibility and short lead times.
- High-volume production takes place in China for lowest possible cost.

1.4 Other QuickStart Boards and Kits

Visit Embedded Artists' home page, www.EmbeddedArtists.com, for information about other *QuickStart* boards / kits or contact your local distributor.

2 Board Design

This chapter contains detailed information about the electrical and mechanical design of the *LPC2148 USB QuickStart Board*. A number of example circuits are also presented that will lower the threshold of start developing applications with the board.

2.1 Board Schematics

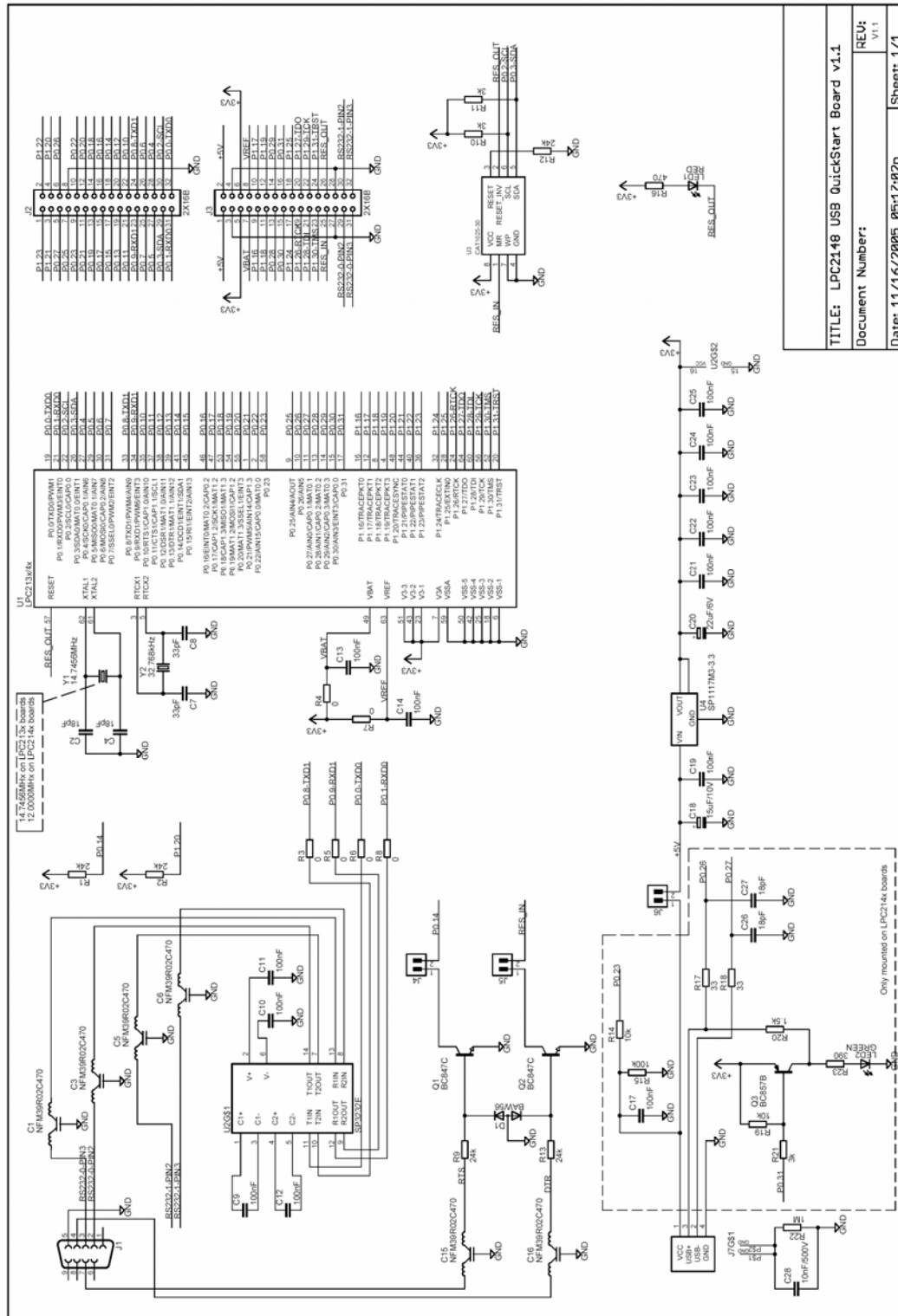


Figure 1 - LPC2148 USB QuickStart Board Schematic

Besides the LPC2148 microcontroller from Philips, the board contains an USB interface, a 3.3V low-dropout voltage regulator, a 2 Kbit I²C E²PROM with reset generation, and an ESD/EMI protected RS232 serial channel. Both UART channels on the processor can use the RS232 interface. Only UART #0 is however connected to the DSUB-9 connector. A red LED is connected to the reset signal and lights when reset is active, i.e., the signal is low. Power can either be supplied via the expansion connector or via the USB connector. Powering via the USB connector should only be used if the external power need is limited to 100-150 mA. If the board is powered from the USB interface jumper J6 must be inserted (see schematic above). Also observe that it is not allowed to both power the board from the USB interface and from an external source (+5V DC). The USB interface (typically on the PC-side) can get damaged in that case. The USB interface supports the Soft Connect functionality and voltage sense (see LPC2148 User's Manual for more information about these functions).

The microcontroller crystal frequency is 12.0000 MHz. This frequency has been selected in order to allow maximum execution speed ($5 \times 12 \text{ MHz} = 60 \text{ MHz}$, which is the maximum frequency). The on-chip UART peripheral includes a fractional baud rate generator that allow standard baud rates to be generated from the 60 MHz base clock. The USB clock is also generated from the 60 MHz clock without any problems.

The crystal frequency can be changed to any desired value for OEM orders, provided that the conditions in the LPC2148 datasheet are met. Current requirements are (but consult the most current datasheet for latest details):

- 1-30 MHz if the on-chip phase-locked loop (PLL) is not used, or
- 10-25 MHz if the PLL is to be used.

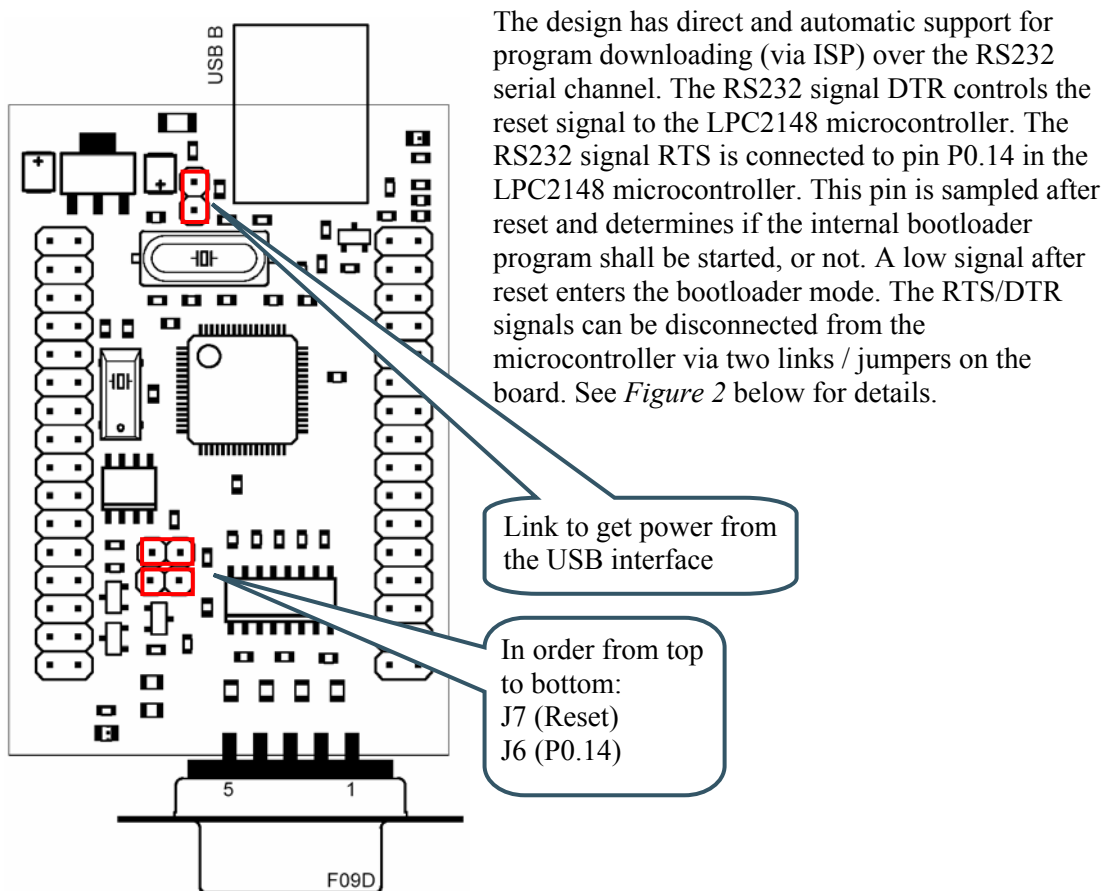


Figure 2 - LPC2148 QuickStart Board ISP Jumpers

The board interface connectors are placed in two 2x16 pin rows along the board edges. They are 1200 mil (30.48 mm) apart. *Figure 3* below illustrates the two row connectors and their signals.

Observe that P0.26 and P0.27 are the USB signals and should normally be left unconnected, unless an external USB connector is implemented. Sometimes P0.23 is also used by the application and should also in this case be left unconnected.

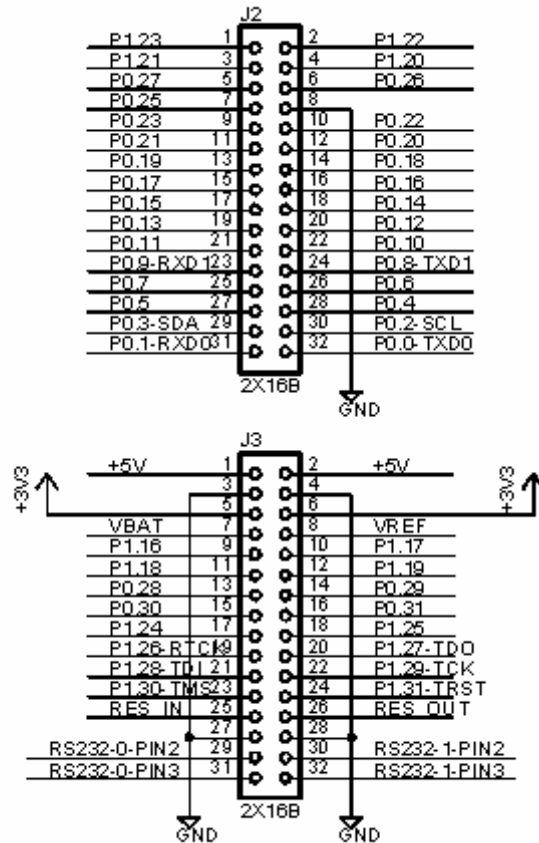


Figure 3 - LPC2148 QuickStart Board Interface Connectors

2.3 Examples

This section contains a few sample / illustrative circuit examples that will help you to quickly get up-and-running with the board interface design. Detailed information about the on-chip peripheral units can be found in the LPC2148 User's Manual.

2.3.1 JTAG

The LPC2148 microcontroller contains a JTAG interface that can be used for debug purposes during program development. The circuit in *Figure 5* below works for many JTAG interfaces on the market, including CrossConnect from Rowley Associates, J-link from Segger, Ulink from Keil, and Wiggler from MacRaigor.

The signal RTCK on the LPC2148 microcontroller is sampled during reset. Jumper J5 drives the signal low. If the signal is found low, the JTAG interface is enabled. Pin P1.26-P1.31 then changes from being general I/O pins to dedicated JTAG pins.

Note that many Wiggler JTAG interfaces do not work with a processor crystal frequency above about 10 MHz. If this is the case, the crystal frequency can be changed by desoldering the 12.0000 MHz crystal and replace it with another suitable one.

LPC2148 QuickStart Board

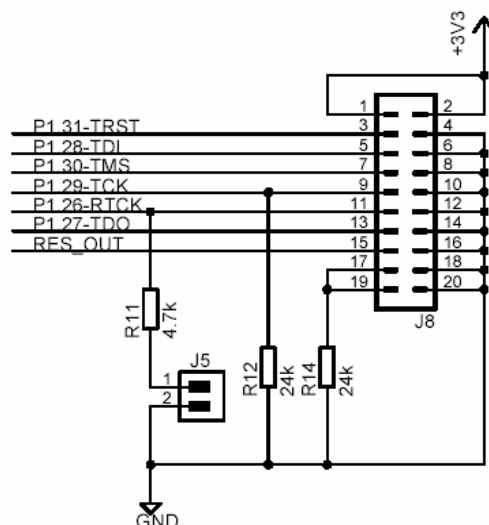
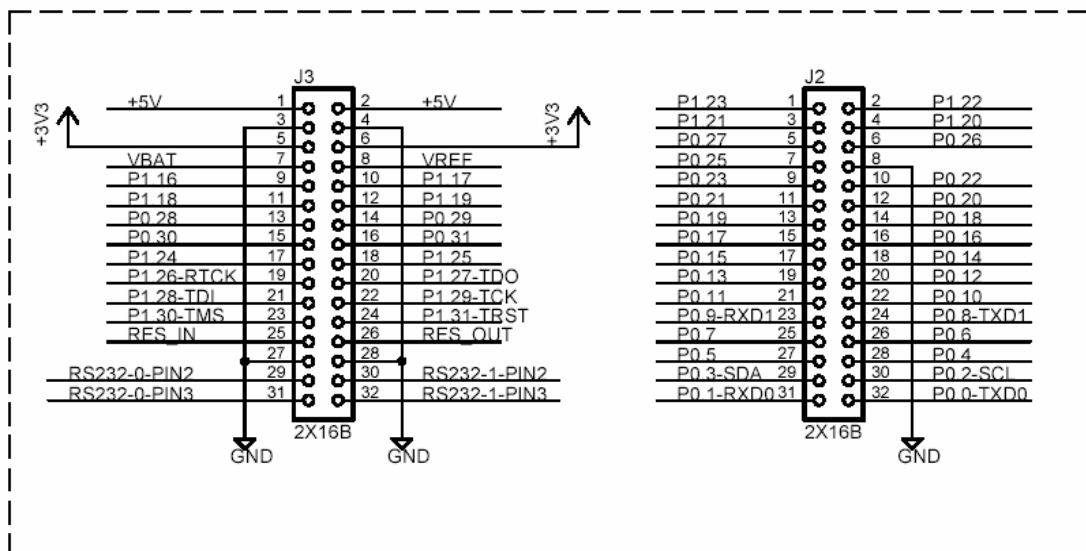


Figure 5 – Example JTAG Interface

2.3.2 Reset

The on-board I2C E2PROM (CAT1025) also contains a reset generator. The reset signal will be held active (i.e., low) until the supply voltages, +3.3V, is within margins. The reset duration is typically 200 mS (consult the CAT1025 datasheet for exact details). The output reset signal is an open-collector / open-drain output. An external reset source can also control the reset generator. *Figure 6* below illustrate how an external push-button can generate a reset. Observe that an external driver should be an open-collector / open-drain driver.

LPC2148 QuickStart Board

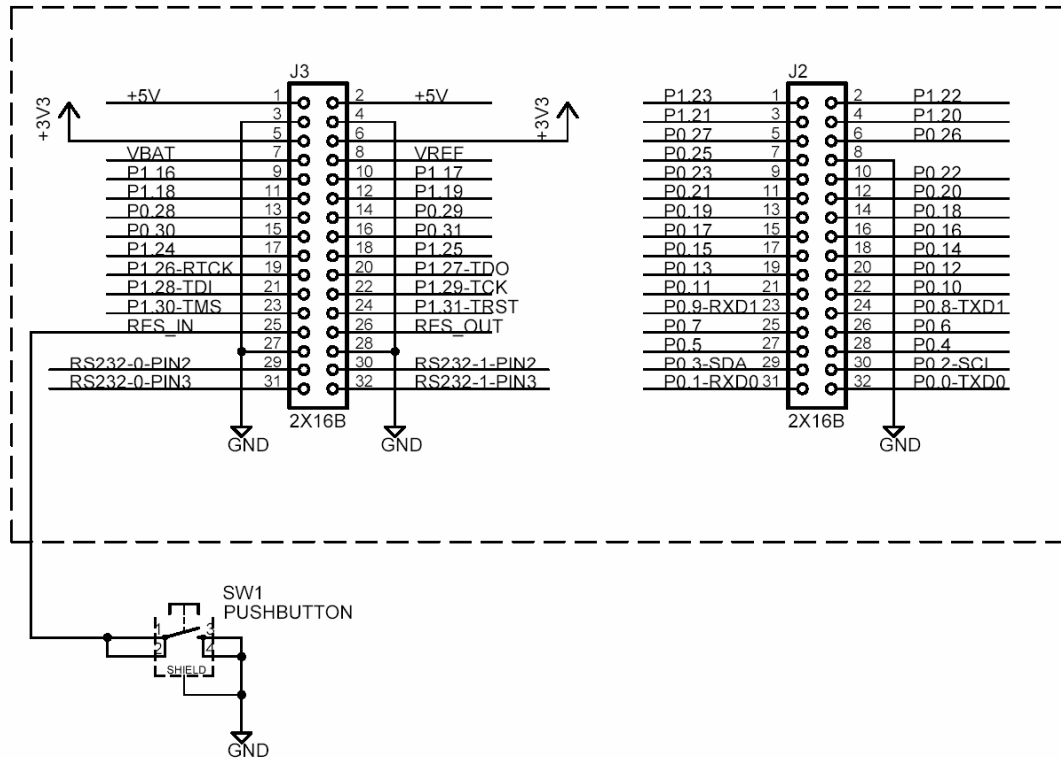


Figure 6 – Example External Reset Push-button

2.3.3 I²C

The LPC2148 microcontroller has an on-chip I²C communication channel (actually two, but one is used and the other is optional). The *LPC2148 USB QuickStart Board* has connected a 2 Kbit E²PROM to this bus. More peripheral units are easily connected to the two-wire I²C bus. *Figure 7* below illustrates how a pin expander circuit (PCF8574) can be connected to the I²C bus.

LPC2148 QuickStart Board

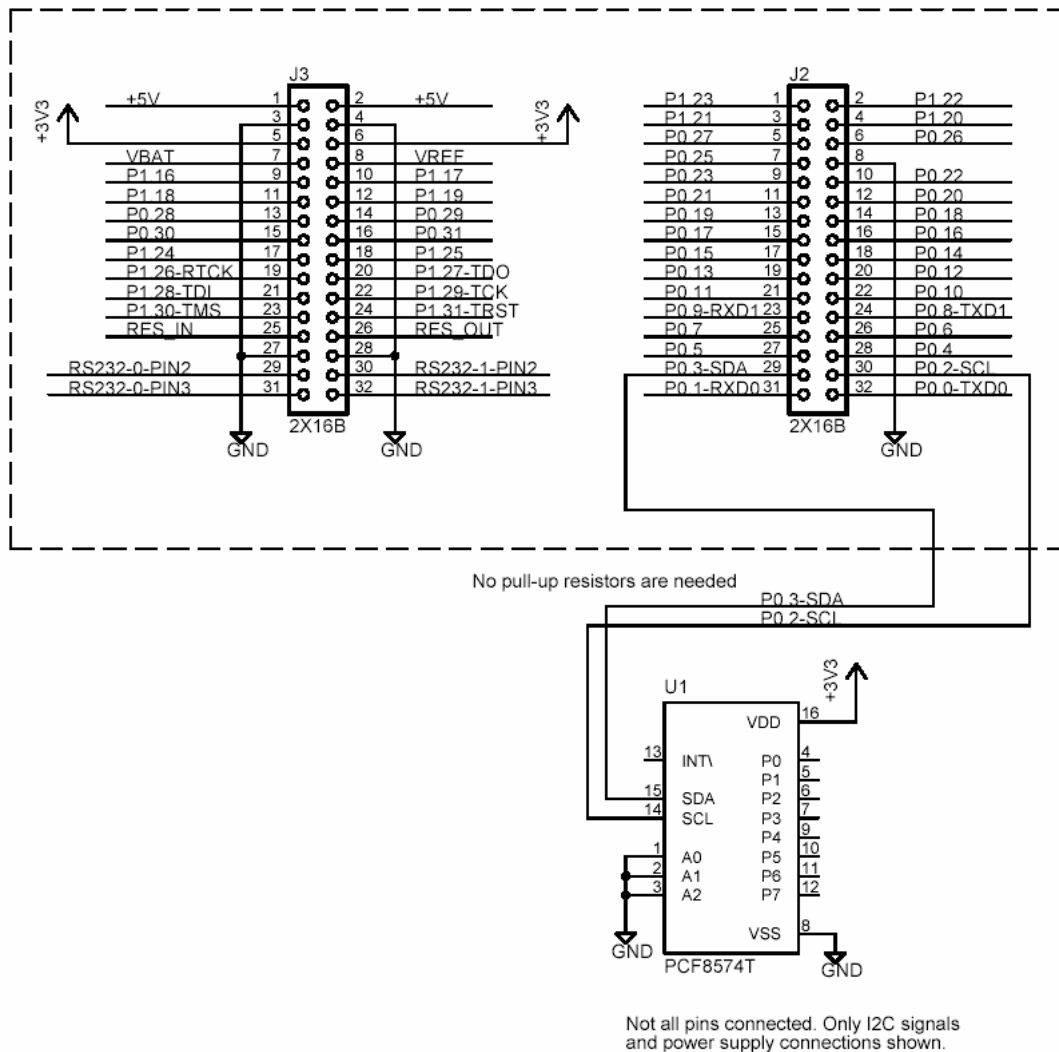


Figure 7 – Example I²C Interface

Observe that the pull-up resistors (which are always needed on I²C busses) are included on the *LPC2148 USB QuickStart Board*, and are hence not needed on the external circuit. The pull-up resistors are 3000 ohm each (see *Figure 1* for complete board schematics).

If using the second I²C channel do not forget to connect pull-up resistors to these signals also. Note that this must be done even if the I²C functionality is not used/enabled. Pins P0.11 and P0.14 are open-drain I/Os and must have pull-up resistors when configured as outputs. This is unfortunately easy to forget.

2.3.4 SPI

The LPC2148 microcontroller also has two on-chip SPI serial communication channels. *Figure 8* below illustrates how serial E²PROM chip, a shift register and a SD/MMC memory card are connected to the *LPC2148 USB QuickStart Board*. In the schematic below, signal SSEL (i.e. P0.7) has been pulled high. This is normally required when the SPI controller operates as a 'master', and 'master' operation is typically the normal operating mode. Observe however that for the LPC214x series, SSEL is no longer required to be pulled high when operating as a SPI master. It can be used as a general purpose I/O. A good use for this pin is to use it as chip select for (one of) the SPI slave(s) to communicate with.

In *Figure 8* below, signal P0.30 is used as an example to control the chip select to the serial E²PROM chip, but for the LPC214x series, it could just as well have been the P0.7 (SSEL) pin (or any other pin). Observe that one chip select signal is required for each external chip that is connected to the SPI bus.

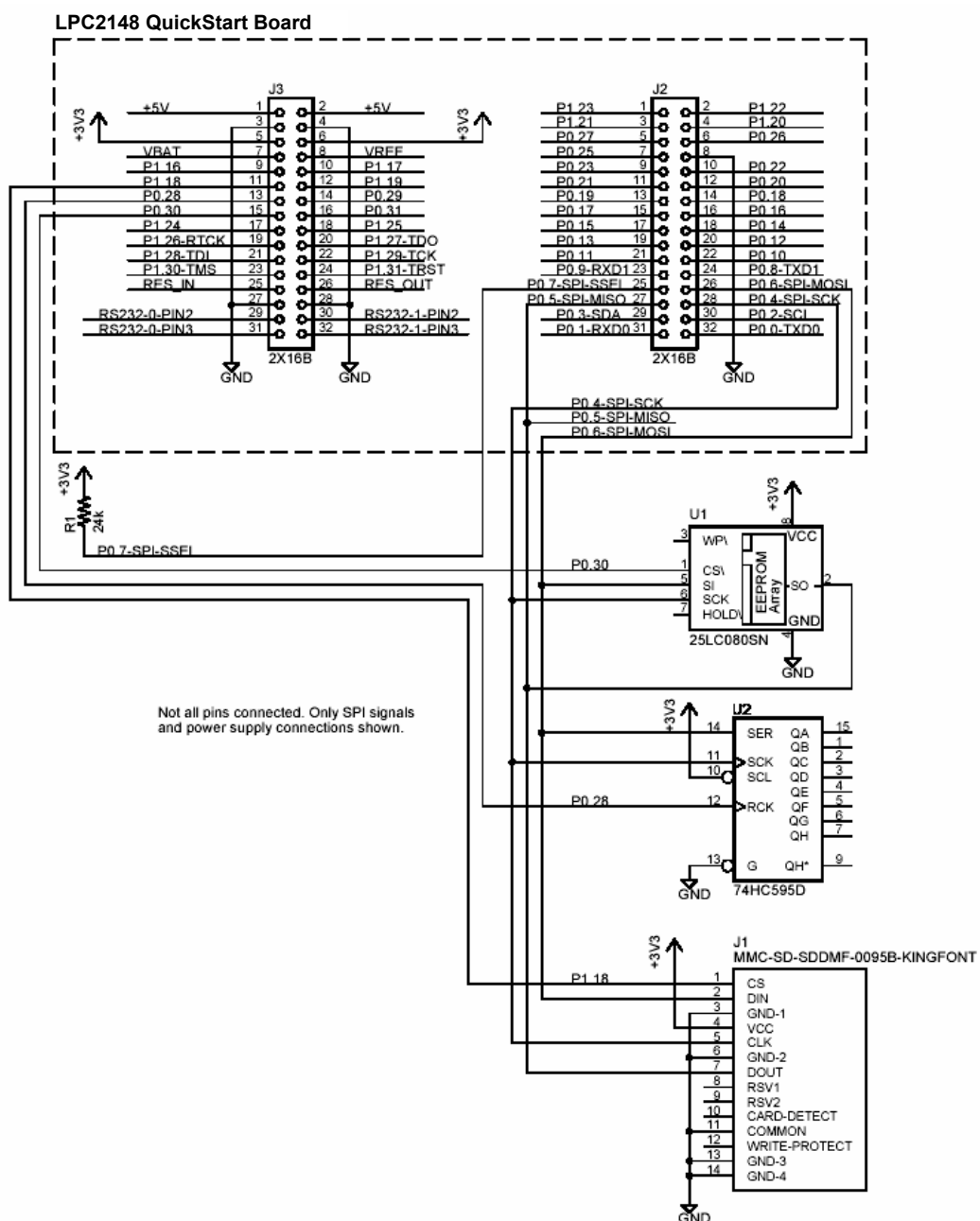


Figure 8 – Example SPI Interface

2.3.5 LEDs

The port pins of the LPC2148 microcontrollers have a 4 mA driving capacity, just enough to directly drive LEDs. *Figure 9* below illustrates how current is sourced from / sink to the microcontroller to drive the LEDs. The resistors limit the current to about 4 mA. The preloaded test program (described in *Section 3.1*) outputs a running-zero on all the port pins (P0.4 – P0.31, P1.16 – P1.31, except the USB pins). A circuit like the one in *Figure 9* below can be used to verify correct operation (use “active low” circuit).

LPC2148 QuickStart Board

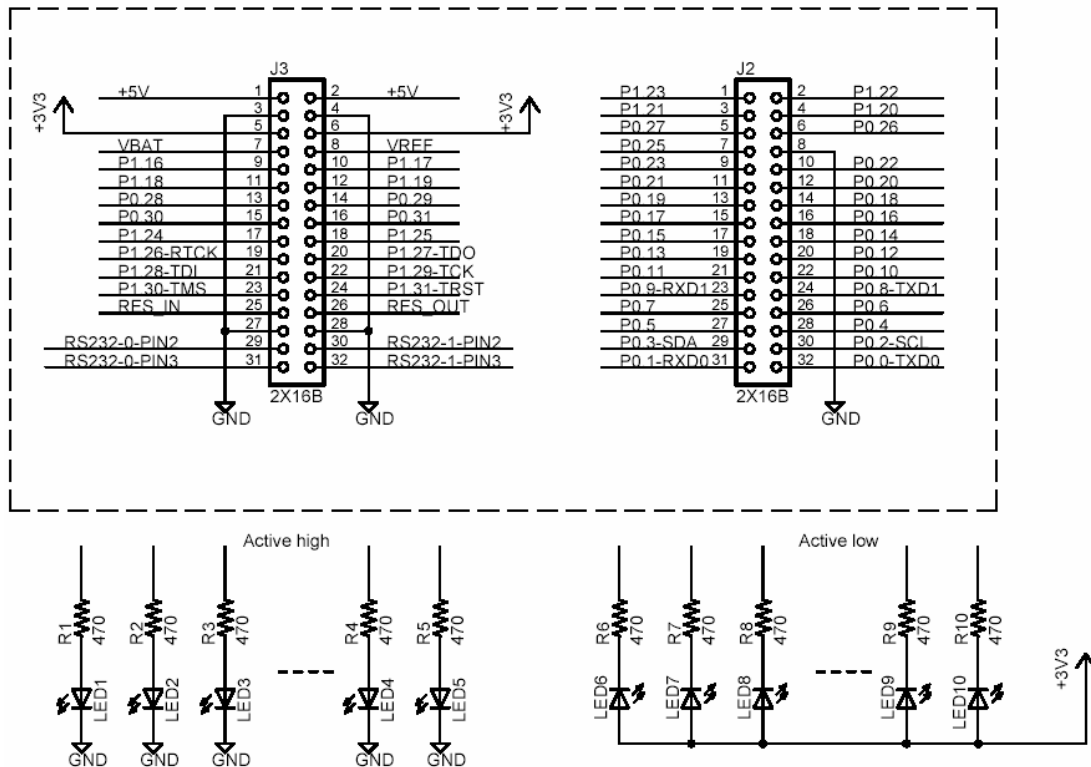


Figure 9 – Example LED Driving

3 Getting Started

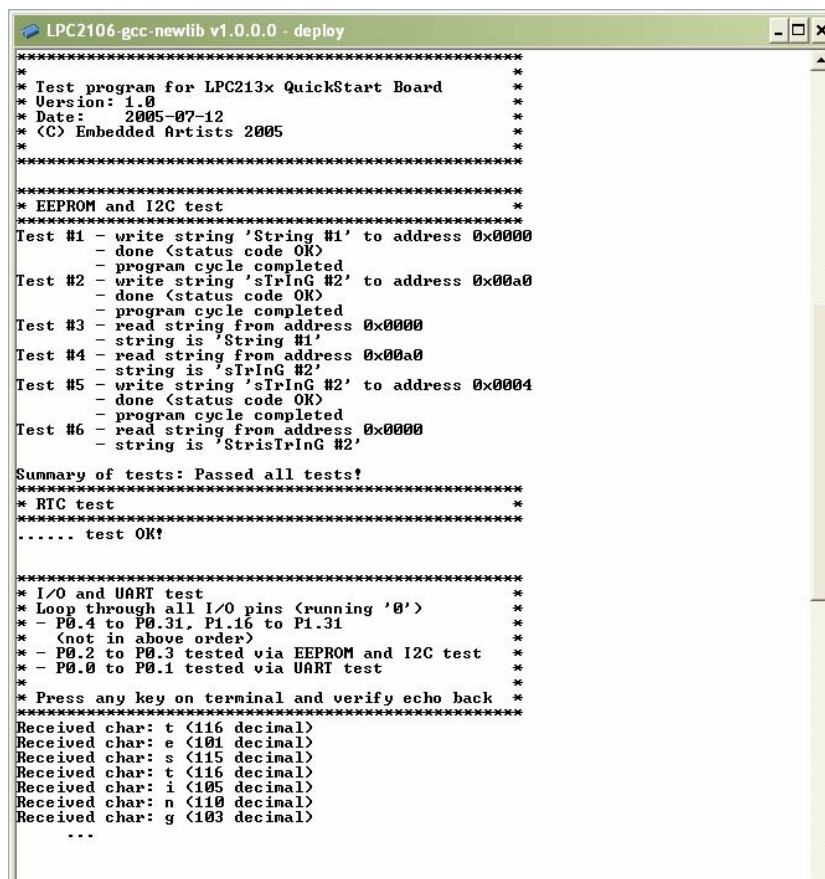
3.1 Test program

The *LPC2148 USB QuickStart Board* comes preloaded with a test program. This program can be used to verify that the board operates correctly. A circuit, like the one found in *Figure 9* above, can be used to attach LEDs to port pins P0.4 – P0.31, P1.16 – P1.31 (except the USB pins). Pins P0.0 – P0.1 are tested via the serial channel and pins P0.2 – P0.3 are tested via the I²C bus. Connect also a USB cable between the *LPC2148 USB QuickStart Board* and a PC. The PC will react to the connection and signal that it has found new hardware.

The test program outputs a running-zero to the port pins, meaning that one LED at a time will light (in a running-one pattern). Also, a terminal program should be attached to the RS232 DSUB-9 connector. The test program will output test information regarding the I²C and E²PROM test. Also, the UART/RS232 channel can be tested by typing characters in the terminal program.

The settings for the terminal program are: 38.4 kbps, 8 data bits, no parity bits, and one stop bit (i.e., 8N1).

The output from the test program will look something like in *Figure 10* below. Observe that the picture below is just an example and not the actual output text.



```

LPC2106-gcc-newlib v1.0.0.0 - deploy
*****
* Test program for LPC213x QuickStart Board
* Version: 1.0
* Date: 2005-07-12
* (C) Embedded Artists 2005
*****

*****
* EEPROM and I2C test
*****
Test #1 - write string 'String #1' to address 0x0000
         - done (status code OK)
         - program cycle completed
Test #2 - write string 'String #2' to address 0x00a0
         - done (status code OK)
         - program cycle completed
Test #3 - read string from address 0x0000
         - string is 'String #1'
Test #4 - read string from address 0x00a0
         - string is 'String #2'
Test #5 - write string 'String #2' to address 0x0004
         - done (status code OK)
         - program cycle completed
Test #6 - read string from address 0x0000
         - string is 'String #2'

Summary of tests: Passed all tests!
*****
* RTC test
*****
..... test OK!

*****
* I/O and UART test
* Loop through all I/O pins (running '0')
* - P0.4 to P0.31, P1.16 to P1.31
*   (not in above order)
* - P0.2 to P0.3 tested via EEPROM and I2C test
* - P0.0 to P0.1 tested via UART test
*
* Press any key on terminal and verify echo back
*****
Received char: t (116 decimal)
Received char: e (101 decimal)
Received char: s (115 decimal)
Received char: t (116 decimal)
Received char: i (105 decimal)
Received char: n (110 decimal)
Received char: g (103 decimal)
...

```

Figure 10 – Example Test Program Output

3.2 Program Development

Consult the *QuickStart Program Development User's Manual* for more information about the *QuickStart Build Environment* from Embedded Artists, and program development for the ARM7 in general.

4 CD-ROM and Product Registration

The accompanying CD-ROM contains a lot of information and programs that will QuickStart your program development! Observe that there may be newer versions of different documents and programs available than the ones on the CD-ROM. See *Section 4.2* for information about the product registration process, which allows you to always have access to the latest versions.

4.1 CD-ROM

The following is included on the CD-ROM:

- The preloaded test program as a HEX-file.
- The two different ISP download programs.
- Datasheets of all circuits on the *LPC2148 USB QuickStart Board*.
- *QuickStart Build Environment* from Embedded Artists, which contains a complete setup of a build environment for GCC.
- A complete development environment: Rowley Associates CrossWorks for ARM, 30-day evaluation version.
- A complete development environment: IAR Embedded Workbench for ARM, Kickstart Edition with 32 Kbyte program size limit.
- Another complete development environment: GCC, GNUARM distribution, including compiler, linker, make, and debugger.
- The program Programmers Notepad, which is a very good program development editor and project manager.
- The Eclipse development environment including the CDT (C/C++ Development Tools) project.

4.2 Product Registration

By registering as a customer of Embedded Artists you will get access to more valuable material that will get you up-and-running instantly:

- Access to a Real-Time Operating System (RTOS), in the form of a library that can be used for non-commercial applications.
- Access to a number of sample applications that demonstrated different (peripheral) functions in the LPC2148 processor.
- Access to the latest versions of all information and programs on the CD-ROM.

Registering is easy and done quickly.

- 1) Go to <http://www.EmbeddedArtists.com>, select *Support* and then *Register*.
- 2) Type in the products serial number (can be found on the *LPC2148 USB QuickStart Board* or on the package carrying the board) along with your personal information.

5 Further Information

The LPC2148 microcontroller is a complex circuit and there exist a number of other documents with a lot more information. The following documents are recommended as a complement to this document.

- [1] Philips LPC2148 Datasheet
http://www.semiconductors.philips.com/acrobat/datasheets/LPC2141_42_44_46_48_1.pdf
- [2] Philips LPC2148 User's Manual
http://www.semiconductors.philips.com/acrobat/usermanuals/UM10139_1.pdf
- [3] Philips LPC2148 Errata Sheet
<http://www.semiconductors.philips.com/acrobat/erratasheets/2148.pdf>
- [4] ARM7TDMI Technical Reference Manual. Document identity: DDI0029G
http://www.arm.com/pdfs/DDI0029G_7TDMI_R3_trm.pdf
- [5] ARM Architecture Reference Manual. Document identity: DDI0100E Book, Second Edition, edited by David Seal, Addison-Wesley: ISBN 0-201-73719-1 Also available in PDF form on the ARM Technical Publications CD
- [6] ARM System Developer's Guide – Designing and Optimizing System Software, by A.N. Sloss, D Symes, C. Wright. Elsevier: ISBN 1-55860-874-5
- [7] Embedded System Design on a Shoestring, by Lewin Edwards. Newnes: ISBN 0750676094.
- [8] GNU Manuals
<http://www.gnu.org/manual/>
- [9] GNU ARM tool chain for Cygwin
<http://www.gnuarm.com>
- [10] An Introduction to the GNU Compiler and Linker, by Bill Gatliff
<http://www.billgatliff.com>
- [11] LPC2000 Yahoo Group. A discussion forum dedicated entirely to the Philips LPC2xxx series of microcontrollers.
<http://groups.yahoo.com/group/lpc2000/>
- [12] The Insider's Guide to the Philips ARM7-Based Microcontrollers, by Trevor Martin.
<http://www.hitex.co.uk/arm/lpc2000book/index.html>

Especially observe document [3]. There exist a number of bugs in the processor that is important to be aware of.

Observe that there can be newer versions of the documents than the ones linked to here. Always check for the latest information / version.

Datasheets for all circuits on the *LPC2148 USB QuickStart Board* are included on the accompanying CD-ROM.